

Improving Machinery Reliability with Oil Mist Technology

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Abstract

This presentation will take a snapshot view of the history of oil mist, what oil mist is, how it is generated, how it works, its benefits and justification, oil mist's environmental performance, and some case histories. The sum and substance of oil mist is that it is effective in improving machinery reliability by typically reducing bearing failures by as much as 90%.

Introduction

Oil mist is an old solution for old lubrication problems. Its invention takes us back to Europe in the late 1930's when the fibers industry had a problem. The high speed spindle bearings were failing at an unacceptable rate. The engineers deduced that the problem was not the bearings as much as it was the lubrication technology. Grease would not work in high speed applications and oil led to excessively high temperatures. Subsequently, oil mist lubrication was invented and the bearing problems were solved.

In the 1960's, oil mist came to North America when it was introduced to the petroleum refineries and petrochemical plants. Companies such as Exxon and Chevron began to apply oil mist to their pump bearings. In the 1970's oil mist began to be applied to electric motors, which brought, contrary to some conventional thought, noticeable reliability improvements.

To date, Lubrication Systems Company has sold over 2,000 major oil mist systems around the world: from the extreme cold of the Canadian far north to the searing heat of the Middle East. Oil mist has become known and respected worldwide as an essential and major component of any process to improve machinery reliability. Some renowned reliability experts have gone so far as to say that it is the most important part of a machinery reliability improvement process.

Description of Oil Mist

So what is oil mist, anyway? One expert has summed it up this way. "Today's oil mist is a cost justified, environmentally clean, centralized lubrication system that continuously and efficiently atomizes oil into small particles and then conveys and delivers the correct amount of the pressurized oil mist lubricant to

bearings and metal surfaces, resulting in improved lubrication, fewer failures/repairs, lower life cycle costs and extended machinery life." Whew!

I know that you must be impressed by now with this definition but, what does all of this cleverly assembled verbiage mean? Well, here goes. Oil mist is generated by introduction of liquid oil and air into the sonic velocities of a vortex throat. There, the oil experiences the mechanical phenomena of shear forces and unstable vibrations of the high angular velocities of the air. Working together, these combined actions ultimately form oil particles or droplets 1 to 3 microns with air.

This oil suspension in dry, instrument air, is a mixture of 1 part oil and 200,000 parts of air. It is a lean, fairly stable mixture and can be conveyed horizontally up to 600 feet in 2 inch galvanized, screwed piping under a pressure of 20 inches of water column. It appears as a thin, cigarette smoke plume. Incidentally, ambient temperatures do not affect oil mist during the 7 minutes maximum it takes for the oil mist to arrive at the bearings.

Why Oil Mist Works

One of the primary failure mechanisms of rolling element bearings is fatigue. Much of the fatigue is caused by dirt and wear particles that approximately the thickness of the oil wedge, hence the clearance of the bearing elements. Obviously, particles thicker than this will not enter into the clearances to cause fatigue. On the other side of things, particles smaller than the oil wedge are not likely to cause fatigue.

You will recall that the oil mist droplets are 1-3 microns in size. Because of their small size, the dirt or wear particles that can cause fatigue will not remain in suspension with the oil mist and will therefore drop out in the oil mist generator. As some have accurately commented, oil mist is the ultimate oil filter.

There is another important factor as to why oil mist works as well as it does. In graduate research done by Texas A&M University, they discovered that, in some cases, pure oil mist deposits a wear resistant, carbonaceous, dry film on the wear surfaces of rolling element bearings. They did not find this layer to be on bearings in conventional splash lubrication service.

OK, so oil mist deposits this layer. So what? One of the concerns of those not familiar with oil mist fear it because of what they think will happen if the oil mist ceases to flow while their machinery is in operation. They think that the bearings will fail immediately. On the contrary, research and field experience have shown that, because of this carbonaceous layer, machinery can safely operate 8 hours without oil mist. Some users have operated safely for periods much longer than that. Certainly, nobody would recommend purposely shutting down oil mist but

there need not be the life or death sense of urgency that one would need with conventional lubrication methods.

Forms of Oil Mist

Oil mist can be applied in two formats: pure mist (dry sump oil mist) or purge mist (wet sump oil mist). With purge mist applications, the oil mist is applied to the vapor space above the liquid oil in primarily gear boxes, oil reservoirs, and journal (plain) bearings. This is done to exclude water and other contaminants. With pure mist applications, the mist replaces the liquid oil in rolling element bearing housings; there is no other lubricant going to the bearings.

Often, users mistakenly believe that purge mist is better because it combines the benefits of both forms; it is a belts and suspenders insurance policy. In fact, pure mist has substantial benefits over purge mist as explained below. Most of the potential benefits are missed with purge mist.

Benefits of Oil Mist Lubrication

There are numerous direct benefits of oil mist, not the least of which is that it reduces bearing failures by 90% with pure mist. One user in West Texas even boasts a 98% reduction. A bearing manufacturer says that the bearing L_{10} life is extended by a factor of 6 by oil mist. It takes little imagination to see that such a drastic reliability improvement will impact the bottom line both in the reduction in expenses and Lost Profit Opportunity. When you consider accounting's Revenue Formula, $Revenue = Income + Liabilities$, you can easily see that oil mist impacts both sides of the equation, namely revenue (increase on-spec product) and liabilities (repair expenses).

In purge mist on cooling tower, angle gear boxes, users typically experience a 75% reduction in gear box failures. This improvement is directly attributable to the slight positive pressure of the oil mist. As cooling tower cells are shut down and as gear boxes go through the inhalation/exhalation cause by thermal cycles, water vapor is inhaled and subsequently condenses. This water causes devastating corrosion which will lead to premature gearbox failure.

Oil mist reduces lubricant consumption by as much as 40% for once through systems. If a closed loop system is used, the oil consumption is reduced by considerably more. Conservation happens because the oil is precisely metered to each bearing: the right amount at the right time. This reduction in oil consumption becomes critical when the lubricant is switched from mineral oils (about \$3 per gallon) to synthetic oils (about \$18 per gallon).

Because there is no liquid oil level and liquid friction, operating temperatures are about 20° F cooler. One user reported a 90° F cooler on a crude unit charge pump. According to bearing manufacturers, there is an inverse relation between bearing life and temperatures: the higher the temperature, the shorter the life. Another collateral benefit is up to a 3% reduction in energy consumption. In virtually all hot oil pumps equipped with bearing cooling jackets, the cooling water can be deleted. This is beneficial because cooling water can actually decrease bearing life. Cooling water shrinks the outer race while the heat conducted down the shaft expands the inner race, making the bearing run hotter because of reduced clearances.

Oil mist requires 47% fewer man hours to operate than do the conventional systems. The extra 53% free man hours can be used to focus on the reason operators are there, to maximize profitable production, and frees up maintenance personnel to focus on reliability improvement.

Environmental, Health, and Safety

Environmental laws, such as California's Rule #1173, titled *Fugitive Emissions of Volatile Organic Compounds (VOC)*, specifically exempt oil mist as a Volatile Organic Compound (VOC). This means that oil mist is not a smog producing mixture. Remember that oil mist is not a vapor but a mixture of very fine oil droplets and air. In time, the oil droplets will drop out of the air.

According to NIOSH publication 81-123-b-0472.pdf says that the "Permissible Exposure Limit (PEL)... is 5 milligrams of mineral oil mist per cubic meter of air (mg/m^3) averaged over an eight-hour work shift." Incidentally, the Canadian Occupational Safety Administration sets oil mist Occupational Exposure Limits at $5 \text{ mg}/\text{m}^3$ for an 8 hour Occupational Exposure Limit (OEL) and $10 \text{ mg}/\text{m}^3$ for a 15 minute OEL. Field measurements and testing never found measurements to be anywhere near close to the imposed limits.

Since oil mist is so lean, 1 part oil to 200,000 parts air, explosions are impossible. For the mixture to burn, the concentration would have to more than 1 to 250. Therefore, oil mist is safe.

Economic Justifications

Because of oil mist's many benefits, there is a relatively high payout and fast return on invested capital. Typically, the payouts are one to two years with one company reporting 7 months.

Case Studies

1. An aluminum refinery in the Gulf Coast has a bank of 34 large fans equipped with pillow block bearings. The failure rate was such that bearings lasted only six months. The bearings were switched to pure oil mist in 1998. To date, there have been no reports of bearing failures.
2. One of the largest oil companies in the world says that they have two similar olefin plants; both have about 200 pumps. They are both operated under the same operating philosophy. One plant has oil mist and the other doesn't. The one without oil mist has an average of 50 pump failures per year. The plant with oil mist has an average of 4 pump failures per year.
3. A Gulf Coast refinery operating unit spent on average \$35,000 per year on pump repairs. They installed oil mist in 1989. Since that time, their pump repairs have averaged < \$5,000 per year.
4. Another refinery had annual pump cost before and after oil mist on selected unit as follows: coker - \$60,000 to \$25,000, cat cracker - \$85,000 to \$28,000, and the crude unit - \$82,000 to \$23,000.
5. In a Philippine refinery, the Mean Time Between Failure of their pumps before oil mist was 3 years. After the installation of oil mist, their MTBF after 6 years of service was > 9 years.
6. There are many more success stories but I will end with a comparison of two similar refineries in Thailand. Both are owned by the same company and, like Case Sty # 2, they have the same operating philosophy and the same reliability improvement programs. The difference between the two is that one does not have oil mist and the other one does. There are the differences between the performance parameters in year 2001:
 - a. Annual oil consumption in liters/bearing/year – 14 versus 5
 - b. Bearing failures as a % of installed bearings – 4.4 versus 0.3
 - c. Seal life (MTBF) in years – 4 versus 9

Conclusions

Oil mist is a proven technology that demonstrates every day around the world that it significantly reduces bearing failures, reduces maintenance costs, improves machinery availability, reduces energy consumption, reduces the need for warehoused repair parts, reduces life cycle costs, and reduces the stress of operating a plant. It not only improves machinery reliability but frees up operators and maintenance personnel to perform their primary functions, to put on spec product out the door and to help make the company a profitable business. Oil mist is discretionary but there is probably not another thing that a plant may do that can achieve these level reliability improvements than as can oil mist lubrication.